BILE BINDING ABILITYAND DIETARY FIBRE OF TWIN-SCREW EXTRUDED MODEL SORGHUM-BARLEY BLEND

S.Y. Sim[1], J. Zhang[1,2], P.A. Sopade[1,2,*]

[1]School of Agriculture & Food Sciences, University of Queensland, QLD 4072
[2]Centre for Nutrition & Food Sciences, University of Queensland, QLD 4072
*Correspondent: E-mail: p.sopade@uq.edu.au

Sunday Mail Brisbane, Brisbane
03 Jun 2012, by Suellen Hinde
General News, page 40 - 620.86 cm²
Capital City Daily - circulation 463,011 (------S)
ID 148536289 PAGE 1 of 2

HEALTHWATCH

WITH SUELLEN HINDE

Against the grain

Sorghum's not just fit for animals

SORGHUM, considered a common feedlot grain in Australia, is being hailed as a secret weapon in the fight against obesity and world food shortages.

The super healthy grain is in the top five cereals in the world but in Australia we feed it to animals or throw it out.

"It is a good source of dietary energy – it is low GI, gluten-free and has a high level of resistant starch, which is great for digestion."

Sorghum also contains a significant amount of polyphenols, known to have anti-cancer properties.

Dr Poulsen said sorghum was drought-tolerant, so it could be grown in areas where agricultural and environmental conditions didn't suit other crops.

India, for things such as flatbreads, but for some reason it is not used here."

Australia's most important

Sorghum for humans

- Sopade PA ... 1992. Rheological characterization of *akamu*, a semi-liquid food made from maize, millet and SORGHUM. *Journal of Cereal Science* **15**: 193.
- …
- … Sopade PA ... 2010. Kinetics of starch digestion and functional properties of twin-screw extruded SORGHUM. *Journal of Cereal Science* **51**: 392.

Sorghum for humans ...

Sorghum

- Least digestible of the cereals (cf. glycemia).
- Pronounced starch-protein interactions.
- Gluten-free (cf. gluten intolerance).
- Contains phenolic compounds (cf. antioxidants).
- Dietary fibre.

(Yousif *et al.*, 2012)

Grains can be mixed to combine their benefits.

Barley

- Important for its β-glucans and arabinoxylan (dietary fibre). (Sharma & Gujral, 2010)

Sorghum for humans ...

Research into
Material-processing-digestibility-health properties
of sorghum(-barley) mixtures.

- Food processing
  - Extrusion cooking.
    - Widely used in the cereal industry.
    - Breakfast, snacks and ready-to-eat (RTE) foods.
    - Single and twin-screw extruders.
    - Heat-moisture-pressure-shear effects.

Sorghum for humans ...

From the research, for this conference:

- Koa SS, Jin X, Zhang J, Sopade PA. Extruder response and properties of extrudates from a model sorghum-barley blend (Poster).
- Li Y, Sopade PA. Kinetics of protein digestion and molecular weight profiles in a model sorghum-barley blend as affected by extrusion conditions (Poster).
- Koa SS, Sopade PA. Dependence of phytochemical and antioxidant properties of extrudates from a model sorghum-barley blend, on extrusion conditions (Poster).
- Sim SY, Zhang J, Sopade PA. Bile binding ability and dietary fibre of twin-screw extruded model sorghum-barley blend.

Dietary fibre and bile acids

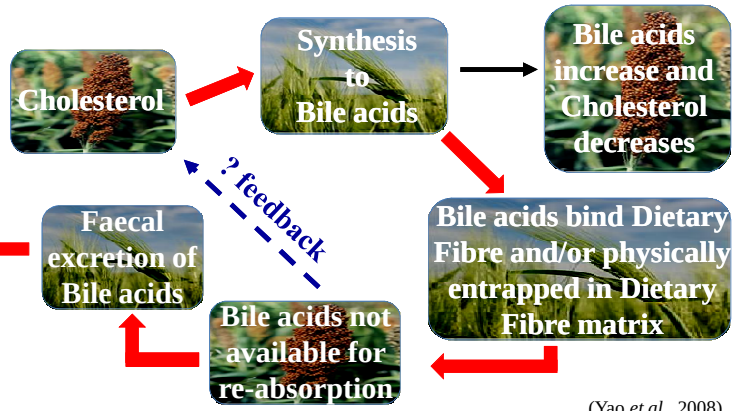
Cereals

- …
- Dietary fibre

- Non-digestible (polysaccharides)
- Soluble
- Insoluble
- **Bile acid metabolism**
- **Lower cholesterol level**

- Acidic steroids
- Emulsify dietary fats.
- Synthesized from cholesterol.
- Reabsorbed in the terminal ileum.

Dietary fibre and bile binding



(Yao *et al.*, 2008)

Aims and hypotheses

Aim

- To investigate bile binding and dietary fibre in extruded food systems.

Hypotheses

- Bile binding is directly related to dietary fibre.
- Extrusion increases bile binding.

Materials & Methods

- **Materials**
  - Red sorghum (genotype *Maxi*), and brown barley (genotype ND19119) from QDAFF, Alexandria Hill.
  - The grains were hammer-milled with a 3-mm retention sieve before mixing in a ratio 60 (sorghum):40 (barley).

Materials & Methods ...

- **Extrusion cooking**
  - Prism Eurolab KX16 twin-screw extruder .
  - Randomised partially replicated experimental design:
    - Moisture (%): 20, 25, 30, and 40
    - Temperature (°C): 110, 140 and 160.
    - Feed rate (kg/h): 2,3,4, and 5.
    - Screw speed (rpm): 150, 220 and 300.

Extrudates and non-extrudates were cryo-milled for analysis.

Materials & Methods ...

Dietary fibre analysis (Megazyme™ K-TDFR procedure)

Digestion with α-amylase, protease & amyloglucosidase

Centrifugation

Alcohol precipitation

Filtration: 0.45µm nylon filter paper

Protein & ash analyses

Calculate IDF, SDF, TDF

Materials & Methods ...

Bile binding analysis

Digestion

↓

Add Bile acids & porcine pancreatin ← **Bile acids**
- Sodium cholate (35%)
- Sodium deoxycholate (35%)
- Sodium glycholate (15%)
- Sodium taurocholate (15%)

↓

Centrifugation

↓

Analyse unbound Bile acids using the Bile Acid Diagnostic Kit (Trinity Biotech Procedure No.450)

(Kahlon *et al.*, 2009; Kim & White, 2009)

Materials & Methods ...

Bile binding analysis …

NAD + Unbound bile acids (3α-hydroxybile acids)

↓ 3α-hydroxysteroid dehydrogenase

3-oxo Bile acids + NADH

NADH + NBT

- Nicotinamide adenine dinucleotide (NAD)
- Nitro blue tetrazolium salt (NBT)

↓ Diaphorase

NAD + **Formazan**

(Spectrophotometry at λ_{MAX} = 530 nm)

Materials & Methods ...

Experimental design/Statistical analysis
- Randomised and duplicated
- Full and/or partial factorial design
- Minitab®
  - ➢General Linear Model (ANOVA)

Results & Discussions

Extrusion-Dietary fibre-Bile binding*

Parameter (%)	Feed rate (kg/h)				Temperature (°C)		
	2	3	4	5	110	140	160
TDF	16.4[a]	15.8[a]	17.7[a]	17.1[a]	17.8[a]	16.4[a]	17.9[a]
IDF	14.6[a]	13.5[a]	15.4[a]	15.5[a]	14.9[a]	14.6[a]	15.7[a]
SDF	1.8[ab]	2.3[a]	2.3[a]	1.7[b]	2.9[a]	1.8[b]	2.2[b]
BB[+]	86.6[a]	80.0[a]	75.5[a]	74.8[a]	88.4[a]	86.6[a]	82.0[a]

*Values with the same letters are not significantly (p>0.05) different
[+]Relative to cholestyramine (100%)

Extrusion-Dietary fibre-Bile-binding* ...

Parameter (%)	Moisture (%)				Screw Speed (rpm)		
	20	25	30	40	150	220	300
TDF	19.0[a]	18.3[a]	16.8[a]	17.8[a]	18.8[a]	17.6[ab]	16.5[b]
IDF	16.8[a]	15.9[a]	14.5[a]	15.3[a]	16.0[a]	14.3[b]	15.4[ab]
SDF	2.2[a]	2.4[a]	2.3[a]	2.1[a]	2.4[a]	2.2[a]	2.2[a]
BB[+]	75.6[a]	69.4[a]	72.4[a]	68.6[a]	60.2[a]	74.7[a]	75.6[a]

*Values with the same letters are not significantly (p>0.05) different
[+]Relative to cholestyramine (100%)

Extrusion- Dietary fibre-Bile binding ...

For example, effects of extruder screw speed:

Screw speed ↑ Frictional heat ↑ Shear effects ↑

Melt temperature ↑ Melt viscosity ↓ Molecular degradation ↑

Digestibility ↑

Extrusion- Dietary fibre-Bile binding ...

For example, effects of extruder screw speed:

Screw speed ↑ Frictional heat ↑ Shear effects ↑

Melt temperature ↑ Melt viscosity ↓ Molecular degradation ↑

Digestibility ↑

$$SME = \left(\frac{SS}{SS_{MAX}}\right) \times \left(\frac{\Gamma}{100}\right) \times \left(\frac{P_R}{G}\right)$$

Parameter	150 rpm	220 rpm	300 rpm
SME kJ/kg	278[a]	318[a]	346[a]
Melt Temp	99[a]	101[a]	103[a]
$StDig_{4hr}$	92[a]	94[a]	89[a]

Extrusion- Dietary fibre-Bile binding ...

For example, effects of extruder screw speed:

Screw speed ↑ Frictional heat ↑ Shear effects ↑

Melt temperature ↑ Melt viscosity ↓ Molecular degradation ↑

Digestibility ↑

Dietary fibre ↓

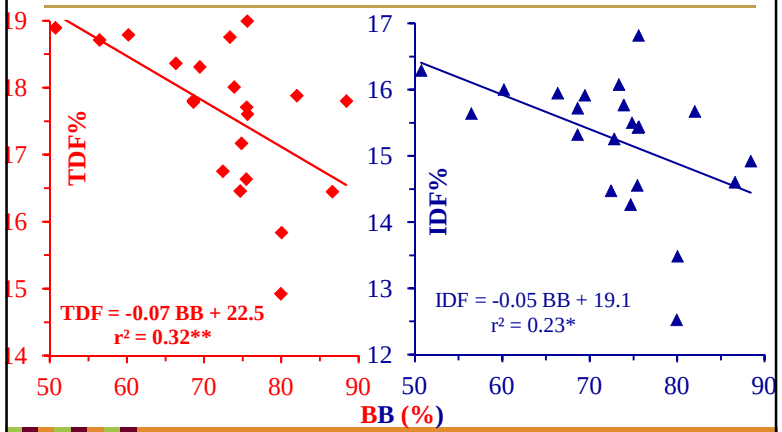
Bile binding ↓ ✖

(Are there structural and/or molecular issues?)

Parameter	150 rpm	220 rpm	300 rpm
SME kJ/kg	278[a]	318[a]	346[a]
Melt Temp	99[a]	101[a]	103[a]
$StDig_{4hr}$	92[a]	94[a]	89[a]
TDF	**18.8[a]**	**17.6[ab]**	**16.5[b]**
BB	**60.2[a]**	**74.7[a]**	**75.6[a]**

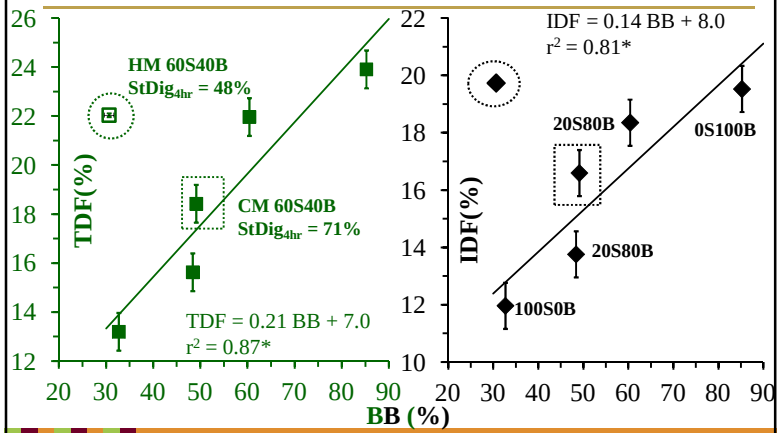
Centre for Nutrition & Food Sciences

Dietary fibre-Bile binding: Extrudates



Centre for Nutrition & Food Sciences

Dietary fibre-Bile binding: Non-extrudates



Centre for Nutrition & Food Sciences

Dietary fibre-Bile binding

- With the extrudates, BB inversely related to DF.
- **BUT** with the non-extrudates, BB directly related to DF.
- Expected as the extrudates were structurally different from the non-extrudates.
- The barley had more DF than the sorghum as expected.

Centre for Nutrition & Food Sciences

Dietary fibre-Bile binding ...

- There were particle size effects:
  - The hammer-milled 60S40B had lower starch digestibility and higher DF, but lower BB than the cryo-milled 60S40B.
  - The lower BB was possibly due to less entrapment of the bile salts resulting from a loose or less-compact particle-particle arrangements in the hammer-milled blend.

Conclusions

- Extrusion cooking increased BB ability (extrudate = 72% ± 1.8; non-extrudate = 49% ± 3.7), reduced IDF (extrudate = 15% ± 0.7; non-extrudate = 17% ± 0.8), but did not change SDF (extrudate, non-extrudate = 2% ± 0.1).
- Extrusion reversed the direct relationship between DF and BB possibly because of structural and molecular changes.

Conclusions ...

- With the 60% sorghum 40% barley, extrusion at 2 kg/h, 20% moisture, 300 rpm, and 110^{o}C would enhance the bile-binding ability of the product.
- Processing influences nutraceutical properties of food, and with sorghum for humans, solely or combined with other grains, effects of processing on its desirable properties need to be ascertained.

Acknowledgements

- Su Sin Koa (UQ)
- Zinglin Jin (UQ)
- Hugh Rodrigues (DAFF)